5. ENVIRONMENTAL BASELINE

5.1 Introduction

The status of the ESA-listed salmonids in the Project area, and their risk of extinction, have not significantly changed since the species were listed. NMFS is not aware of any new data that would indicate otherwise. The environmental baseline, to which the effects of the proposed action are added, "include the past and present impacts of all Federal, state or private activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation process" (50 C.F.R. 402.02).

NMFS concludes that not all of the biological requirements of the ESA-listed species within the action area are being met under current conditions. Based on the best available information on the subject species' status, including population status, trends, and genetics, and the environmental baseline conditions within the action area, significant improvement in habitat conditions is needed to meet the biological requirements for the survival and recovery of the species. A substantial proportion the tidal marsh and swamp habitats that support migration, smoltification, and rearing have been lost or degraded by shoreland development, diking, dredging, and filling activities. A primary goal of habitat restoration in the Lower Columbia River and estuary is to increase the survival and recovery of salmon by restoring the spatial and temporal diversity and connectivity of habitats available that provide these biological requirements.

The discussion of the Environmental Baseline, below, is presented in two sub-sections. The first sub-section provides an overview of the current environmental conditions in the Lower Colombia River and estuary. The second sub-section provides current information on ESA-listed salmonids of the Lower Columbia River and estuary, and discusses the importance of the Lower Columbia River and estuary's physical processes and resultant habitats to those species.

5.2 Environmental Condition of the Lower Columbia River and Estuary

The Columbia River is naturally a very dynamic system. It has been affected and shaped over eons by a variety of natural forces, including volcanic activity, storms, floods, natural events, and climatological changes. These forces had and continue to have a significant influence on biological factors, habitat, inhabitants, and the whole riverine and estuarine environment of the Columbia River.

Over the past century, human activities have dampened the range of physical forces in the action area and resulted in extensive changes in the Lower Columbia River and estuary. To a significant degree, the risk of extinction for salmon stocks in the Columbia River Basin has increased because complex freshwater and estuarine habitats needed to maintain diverse wild populations and life histories have been lost and fragmented. Estuarine habitat has been lost or altered directly through diking, filling, and dredging. Estuarine habitat has also been removed indirectly through changes to flow regulation that affect sediment transport and salinity ranges of specific habitats within the estuary. Not only have rearing habitats been removed, but the connections among habitats needed to support tidal and seasonal movements of juvenile salmon have been severed.

The Lower Columbia River estuary has lost approximately 43% of its historic tidal marsh (from 16,180 to 9,200 acres) and 77% of historic tidal swamp habitats (from 32,020 to 6,950 acres) between 1870 and 1970 (Thomas 1983). One example is the diking and filling of floodplains formerly connected to the tidal river, which have resulted in the loss of large expanses of low-energy, off-channel habitat for salmon rearing and migrating during high flows. Similarly, diking of estuarine marshes and forested wetlands within the estuary have removed most of these important off-channel habitats. Sherwood *et al*. (1990) estimated that the Columbia River estuary lost 20,000 acres of tidal swamps, 10,000 acres of tidal marshes, and 3,000 acres of tidal flats between 1870 and 1970.

The total volume of the estuary inside the entrance has declined by about 12% since 1868. This study further estimated an 80% reduction in emergent vegetation production and a 15% decline in benthic algal production. Sherwood *et al*. (1990) also analyzed early navigational charts and noted profound changes in the river entrance from year to year. The pre-development river mouth was characterized by shifting shoals, sandbars, and channels forming ebb and flood tide deltas. Before jetty construction, the navigable channel over the tidal delta varied from a single, relatively deep channel in some years to two or more shallow channels in other years.

Within the Lower Columbia River, diking, river training devices (pile dikes and riprap), railroads, and highways have narrowed and confined the river to its present location. Between the Willamette River and the mouth of the Columbia River, diking, flow regulation, and other human activities have resulted in a confinement of 84,000 acres of floodplain that likely contained large amounts of tidal marsh and swamp. The Lower Columbia River's remaining tidal marsh and swamp habitats are in a narrow band along the Columbia River and tributaries' banks and around undeveloped islands.

Since the late 1800s, the Corps has been responsible for maintaining navigation safety on the Columbia River. During that time, the Corps has taken many actions to improve and maintain the navigation channel. The channel has been dredged periodically to make it deeper and wider, as well as annually for maintenance. To improve navigation and reduce maintenance dredging, the navigation channel has also been realigned and hydraulic control structures, such as in-water fills, channel constrictions, and pile dikes, have been built. Most of the present-day pile dike system was built in the periods 1917-23 and 1933-39, with an additional 35 pile dikes constructed between 1957 and 1967.

The existing navigation channel pile dike system consists of 256 pile dikes, totaling 240,000 linear feet. Ogden Beeman and Associates (1985) termed these Corps activities 'river regulation,' and noted that navigation channel maintenance activities, for a 100-year period before their 1985 report, required closing of river side channels, realigning riverbanks, removing rock sills, stabilizing riverbanks, and placement of river 'training' features. Most of these baseline river training features and habitat alterations were constructed or occurred before any of the current ESA-listed salmonids were placed on the list of endangered and threatened species.

Flow regulation, water withdrawal and climate change have reduced the Columbia River's average flow and altered the seasonality of Columbia River flows, sediment discharge and turbidity, which have changed the estuarine ecosystem (National Research Council, 1996; Sherwood *et al*., 1990; Simenstad *et al*., 1990, 1992, Weitkamp, 1994). Annual spring freshet flows through the Columbia River estuary are approximately one-half of the traditional levels that flushed the estuary and carried smolts to sea, and total sediment discharge is approximately one-third of 19th century levels. For instance, flow regulation that began in the 1970s has reduced the two-year flood peak discharge, as measured at The Dalles, Oregon, from 580,000 cfs to 360,000 cfs (Corps, 1999).

Decreased spring flows and sediment discharges have also reduced the extent, speed of movement, thickness, and turbidity of the plume that extended far out and south into the Pacific Ocean during the spring and summer (Cudaback and Jay, 1996; Hickey *et al*., 1997). Changes in estuarine bathymetry and flow have altered the extent and pattern of salinity intrusion into the river and have increased stratification and reduced mixing (Sherwood *et al*., 1990).

These aforementioned physical changes also affect other factors in the riverine and estuarine environment. Tides raise and lower river levels at least 4 feet and up to 12 feet twice every day. The historical range for tides was probably similar, but seasonal ranges and extremes in water surface elevations have certainly changed because of river flow regulation. The salinity level in areas of the estuary can vary from zero to 34 parts per thousand (ppt) depending on tidal intrusion, river flows, and storms. Flow regulation has affected the upstream limit of salinity intrusion. The salinity wedge is believed to have ranged from the river mouth to as far upstream as RM 37.5 in the past. It is now generally believed that the salinity intrusion ranges between the mouth and RM 30. The riverbed within the navigation channel is composed of a continuously moving series of sand waves that can migrate up to 20 feet per day at flows of 400,000 cfs or greater, and at slower rates at lesser flows. This rate of river discharge is not experienced as often as it was before flow regulation in the Columbia River.

Development has changed the circulation pattern in the estuary and increased shoaling rates. Sediment input to the estuary has declined due to the altered hydrograph and the estuary is now a more effective sediment trap (Northwest Power Planning Council, 1996). Although the Columbia River is characterized as a highly energetic system, it has been changing as a result of development and is now similar to more developed and less energetic estuaries throughout the world (Sherwood, *et al*., 1990).

Water quality is another important aspect the environmental condition of the Lower Columbia River and ecosystem that the potential to affect salmonid's growth and survival. The uptake of toxicants during juvenile salmonid residence in the Lower Columbia River and estuary (NWFSC Environmental Conservation Division 2001) can affect their growth and survival. In field studies, juvenile salmon from sites in the Pacific Northwest show demonstrable effects, including immunosuppression, reduced disease resistance, and reduced growth rates, due to contaminant exposure during their estuarine residence (Arkoosh *et al*. 1991, 1994, 1998; Varanasi *et al*. 1993; Casillas *et al*. 1995a,b, 1998a).

Current environmental conditions in the Columbia River estuary indicate the presence of contaminants in the food chain of juvenile salmonids. Fish from a site near Sand Island, in the mouth of the Columbia River, whole body concentrations of dichlorodiphenyl trichloroethane (DDT) and polychlorinated biphenyls (PCB) were 44 ng/g wet wt (~ 220 ng/g dry wt) and 53 ng/g wet wt (~ 265 ng/g dry wt), respectively (Fig. 6) (NWFSC Environmental Conservation Division 2001). The findings of elevated levels of DDTs and PCBs in stomach contents of fish from Sand Island, however, is clear evidence that fish are being exposed to these contaminants while they are in the estuary. Levels of DDTs in stomach contents were 52 ng/g wet weight, and levels of PCBs were 33 ng/g wet weight. Although the Sand Island samples were collected from a mixed population of hatchery and wild fish and it is likely that DDTs and PCBs in hatchery food make some contribution to contaminant body burdens, the values seen were among the highest levels measured at estuarine sites in Washington and Oregon. By comparison, in the Duwamish estuary, a heavily contaminated industrial estuary near Seattle, mean whole body DDT levels in juvenile Chinook salmon were 25 ng/g wet wt (~125 ng/g dry wt) and whole body PCB levels were 68 ng/g wet wt (~340 ng/g dry wt)[NWFSC Environmental Conservation Division 2001, Fig. 6].

More recently, additional samples were analyzed from salmon collections in 1999 and 2000 (NWFSC Environmental Conservation Division, 2001). These analyses show that concentrations of PCBs and DDTs are consistently elevated in Chinook salmon collected from Sand Island in the mouth of the Columbia River. Measured concentrations of DDTs in salmon bodies ranged from 32 to 56 ng/g dry wt, and concentrations of PCBs ranged from 23 to 160 ng/g dry wt (NWFSC Environmental Conservation Division 2001, Fig. 8). No significant differences in mean concentrations of either of these contaminants were found over the three years during which fish were sampled. Elevated levels of PCBs and DDTs were also consistently found in stomach contents of sampled fish, indicating that juvenile salmon caught near Sand Island are taking these contaminants up in their diet.

The concentrations of PCBs present in Sand Island fish are a cause for concern, because they are approaching or even exceeding estimated threshold tissue concentrations for adverse effects in salmonids (Meador, 2000). These values range from 120-360 ng/g dry wt for fish with total body lipid concentrations of 1 to 3%, which are typical of juvenile salmon collected within Pacific Northwest estuaries. At an average of 265 ng/g dry wt, PCB concentrations in Sand Island fish are well within the range of the effects threshold.

Available data suggest that exposure to polyaromatic hydrocarbons (PAH) may be quite variable in juvenile salmon from the Lower Columbia River. In stomach contents of juvenile Chinook salmon collected near Sand Island in 1998, PAH concentrations were barely detectable, below levels seen in salmon from moderately developed estuaries such as Yaquina Bay and Grays Harbor, and well below levels found in stomach contents of salmon from industrialized waterways of Puget Sound (*e.g.*, Hylebos Waterway) (NWFSC Environmental Conservation Division 2001, Fig. 9). Similarly, concentrations of PAH metabolites in bile were relatively low in juvenile salmon from Sand Island in comparison to fish from urban Puget Sound sites (*e.g.*, the Duwamish and Hylebos Waterways) (NWFSC Environmental Conservation Division 2001, Fig. 10). Juvenile salmon sampled near Sand Island in 2000, however, showed somewhat greater exposure to PAHs than salmon sampled in 1998. Concentrations of PAHs and their metabolites in both stomach contents and fish bile were considerably higher in 2000 than in 1998 (NWFSC Environmental Conservation Division 2001, Fig. 11). Concentrations were still lower than those observed in fish from urban estuaries in Puget Sound, but were comparable to those observed in fish from moderately development estuaries along the Washington and Oregon coasts, such as Yaquina Bay or Coos Bay.

These data indicate that juvenile salmonids within the Columbia River estuary have contaminant body burdens that may already be within the range where sublethal effects may occur, although the sources of exposure are not clear.

5.2.1 Description of the Environmental Baseline for ESA-listed Salmonids the Lower Columbia River and Estuary

All ESA-listed salmonids must pass through the Lower Columbia River, estuary and river mouth twice: Once as juveniles en route to the Pacific Ocean and again as adults when they return to spawn. The Lower Columbia River and estuary serve three primary roles for outmigrating juveniles as they transition from shallow freshwater environments to the ocean possible: (1) A place where juvenile fish can gradually acclimate to salt water; (2) a feeding area (*i.e*., main, and tidal channel, unvegetated shoals, emergent and forested wetlands, and mudflats) capable of sustaining increased growth rates; and (3) a refuge from predators while fish acclimate to salt water.

Thus, though the Lower Columbia River and estuary is important to the survival and recovery of all ESA-listed salmonids, it is particularly important to ocean-type salmon. These stocks may be particularly sensitive to ecosystem changes because of their longer residence times and dependence on this portion of the river for growth and survival. In this consultation, NMFS focused on ocean-type salmon as an indicator of the importance of the Lower Columbia River and estuary to all ESA-listed salmonids. NMFS focused on ocean-type salmon because they are an indicator of the most sensitive salmonid response to changes in estuary and river habitats.

Ocean-type salmon ESUs in the Columbia River include Chinook ESUs (Lower Columbia River, Snake River fall, and Upper Willamette River) and Columbia River chum salmon ESUs. These ESUs are the most likely to be affected by potential impacts of the Project, and thus are discussed in detail below. Ocean-type salmon migrate downstream to and through the estuary as subyearlings, generally leaving the spawning area where they hatched within days to months following their emergence from the gravel. Consequently, subyearlings commonly spend weeks to months rearing within the action area before reaching the size at which they migrate to the ocean.

Young salmonids must undergo a physiological transition and develop enough strength, energy, and reserve capacity to adapt to and survive the physical and biological challenges of the ocean environment, as well as to successfully obtain prey in that environment. Juvenile salmonids appear to reach the threshold for this transitional state at a size of 70 to 100 mm. Before fish reach this size, their ocean survival would be difficult.

The first outbound migrants of the Lower Columbia River fall Chinook and chum may arrive in the action area as early as late February (Herrmann, 1970; Craddock, *et al*., 1976; Healey, 1980; Congleton, *et al*., 1981; Healey, 1982; Dawley, *et al*., 1986; Levings, *et al*., 1986). The majority of these fish are present from March through June. Outbound Snake River fall Chinook begin their migration much farther upstream and arrive in the Lower Columbia River approximately a month later.

Ocean-type subyearlings arrive in the lower river and estuarine portion of the action area at a small size. The earliest migrants can be as small as 30 to 40 mm fork length (*i.e*., from snout to fork in the tail) when they arrive because some of these fish hatch only a short distance upstream from the action area. Later spring migrants are generally larger, ranging up to 50 to 80 mm. Subyearlings from the mid-Columbia and Snake Rivers tend to be substantially larger (70 to 100 mm) by the time they reach the Lower Columbia River. The larger size of the Lower Snake River fall Chinook, compared with the Lower Columbia River Chinook and chum, likely indicates some differences in suitable habitat. The larger subyearlings from the Snake River can likely use a greater range of depth and current conditions than the subyearlings of the Lower Columbia River ESUs can.

Once ocean-type subyearlings arrive in the Lower Columbia River, they may remain for weeks to months. Because these fish arrive small in size, they undergo extended lower river and estuary rearing before they reach the transitional size necessary to migrate into the ocean (70 to 100 mm). This larger size is necessary to deal with the physical conditions and predators they face in the ocean environment, as well as to be successful in obtaining prey in that environment. At growth rates of about 0.3 to 1 mm per day (Levy, *et al*., 1979; Argue *et al*., 1985; Fisher and Pearcy, 1990), the subyearlings require weeks to months to reach this larger size. During this time, young Chinook increase by about 5 to 8 grams per day or approximately 6% of their body weight (Herrmann, 1970; Healey, 1980).

Ocean-type subyearlings migrate through the riverine reach of the action area of the Project during their downstream migration (about 150 kilometers [km]). Because of this, many spend some time rearing within the riverine reach; however, there is considerable variability in the freshwater rearing period of subyearling populations. Some subyearlings spawned in the lower reaches of coastal tributaries migrate almost immediately to marine areas following emergence from the gravel. Other subyearlings rear in freshwater for weeks to months, particularly those spawned well upstream in larger river systems such as the Columbia. The migration rate for subyearlings undergoing the rearing migration through the riverine reach is likely to be a few to ten km per day. Subyearlings migrating directly to the estuary migrate at rates of 15 to 30 km per day (MacDonald, 1960; Simenstad, *et al*., 1982; MacDonald, *et al*., 1987; Murphy, *et al*., 1989; Fisher and Pearcy, 1990). Adult salmon returning to the Columbia River migrate through the river mouth throughout the year. The majority move through this area from early spring through autumn.

A number of physical characteristics in the riverine reach affect the quality and quantity of habitat available for salmonids. These include the availability of prey, temperature, turbidity, and suspended solids. Subyearlings are commonly found within a few meters of the shoreline at water depths of less than 1 meter. Although they migrate between areas over deeper water, they generally remain close to the water surface and near the shoreline during rearing, favoring water no more than 2 meters deep and areas where currents do not exceed 0.3 meter per second. They seek lower energy areas where waves and currents do not require them to expend considerable energy to remain in position while they consume invertebrates that live on or near the substrate.

These areas are characterized by relatively fine grain substrates. However, it is not uncommon to find young salmonids in areas with steeper and harder substrates, such as sand and gravel.

Young Chinook in the Lower Columbia action area consume a variety of prey, primarily insects in the spring and fall and *Daphnia* from July to October (Craddock, *et al*., 1976). *Daphnia* are the major prey during the summer and fall months, selected more than other planktonic organisms. Young salmonids consume diptera, hymenoptera, coleoptera, tricoptera, and ephemeroptera in the area just upstream from the estuary (Dawley, *et al*., 1986). Bottom and Jones (1990) recently reported that young Chinook ate primarily *Corophium, Daphnia*, and insects, with *Corophium* being the dominant prey species in winter and spring and *Daphnia* the dominant prey species in summer. Salmonids commonly feed on *Corophium* males, which apparently are more readily available than the larger females.

Corophium is commonly discussed as a primary prey item of juvenile salmonids in the Lower Columbia River. *Corophium salmonis* is a euryhaline species tolerating salinities in the range of zero to 20 ppt (Holton and Higley, 1984). As shown by the above investigations, it is one of several major prey species consumed by juvenile Chinook under existing conditions. No data are available that indicate its historical role in the diet of Columbia River salmon before substantial modification of the river system. Nutritionally, *Corophium* may not be as desirable as other food sources for young salmon. According to Higgs, *et al*. (1995), gammarid amphipods such as *Corophium* are high in chitin and ash and low in available protein and energy relative to daphnids and chironomid larvae.

Subyearling Chinook and chum first enter the estuary at about the same time that they enter the riverine potion of the Lower Columbia River because some of the fry move rapidly to the estuary by mid-March rather than rearing in the riverine areas (Craddock, *et al*., 1976; Dawley, *et al*., 1986; Levy and Northcote, 1982; Healey, 1982; Hayman, *et al*., 1996). As Chinook fry migrate to the estuary, they may remain in the low salinity or even freshwater areas for some time until they have grown somewhat larger (more than 75 mm) (Kjelson, *et al*., 1982; Levings, 1982; Levy and Northcote, 1982; MacDonald, *et al*., 1986; Shreffler *et al*., 1992; Hayman, *et al*., 1996). However, some Chinook fry appear to move immediately to the outer edges and higher salinity portions of the estuary (Stober, *et al*., 1971; Kask and Parker, 1972; Sibert, 1975; Healey, 1980; Johnson, *et al*., 1992; Beamer, *et al*., 2000).

Ocean-type fish commonly have the capacity to adapt to highly saline waters shortly after emergence from the gravel. Tiffan, *et al*. (2000), determined that, once active migrant fall Chinook passed McNary Dam 470 km upstream from the Columbia River's mouth, 90% of the subyearlings were able to survive challenge tests in 30 ppt seawater at 18.3°C. Other investigators have found that very small Chinook fry are capable of adapting to estuarine salinities within a few days (Ellis, 1957; Clark and Shelbourn, 1985). Wagner, *et al*. (1969), found that all fall Chinook alevins tested were able to tolerate 15 to 20 ppt salinity immediately after hatching.

While tidal exchange with the ocean tends to keep estuary temperatures at moderate levels (ten to 20˚ C) throughout the time the outmigrants are present, spring and summer temperatures vary widely in shallow water when tidal flats are exposed by low tides during sunny midday periods. Consequently, young salmonids rearing in shallow water naturally experience a wide range of temperatures within periods of less than a day. The available observations of the behavioral reaction of young salmonids to temperatures in estuarine conditions are variable. Bessey (1976) found hatchery Chinook and wild chum avoided water of 16°C. These fry responded immediately to increases of less than 1°C; however, the fry did not avoid rapid increases of more than 1°C per minute. Temperatures in the estuarine reach may range from zero to 26°C, but 12° to 14°C is optimum for young salmon (Bottom, *et al*., 2001).

In the estuary, turbidity is important in relation to the ETM zone. Relatively high turbidity is a characteristic of the intermixing of freshwater and saltwater in the ETM. However, Jones, *et al*. (1990), concluded that, in the Lower Columbia River, the standing stocks of benthic animals were highest in the protected tidal flat habitats, while those of epibenthic and zooplanktonic organisms were concentrated within the ETM. Because prey species have differing tolerances for salinity, increased salinity in the estuary results in different prey species being available to the rearing fry than those in the freshwater riverine reach, and in a change in the abundance of those prey species that are found in both the estuarine and riverine reaches.

In addition, young salmonids in the estuary continue to eat many of the same organisms as are consumed in the riverine reach of the Lower Columbia River, but there are shifts in prey abundance. Young Chinook and chum at Miller Sands in the upper estuarine reach feed primarily on the pelagic prey *Daphnia longispina* and *Eurytemora hirundoides,* the benthic prey *Corophium salmonis*, and chironomid larvae and pupae (McConnell, *et al*., 1978). Diet overlaps considerably among the different species. Many yearlings passing through the lower river were found to have empty or less than full stomachs (Dawley, *et al*., 1986).

As young salmonids leave the estuary, they migrate through the river mouth. At the river's mouth, there tends to be more wave and current energy than other portion of the estuary. The ocean area immediately outside the river mouth is characterized by high salinity during low to moderate flows and by high wave energy with no shoreline for protection. It is likely that young salmonids pass through the river mouth from March through the autumn months during the same time they are present in the estuary. Some individuals may migrate out of the estuary early and other late in the general migration period of each ESU.

Outside the river mouth, young salmonids enter the ocean, where high salinity and the absence of available shoreline require them to adapt to a pelagic life style. Pearcy, *et al*. (1990), found Chinook in near-surface waters up to 46 km offshore from Oregon and Washington during the summer months, but absent from this area by mid-September. Orsi, *et al*. (2000), found juvenile Chinook, chum, and pink salmon were most abundant in the shoreline (strait) waters of southeast Alaska during June and July when zooplankton abundance was highest. Food availability may also be a factor in the timing of Columbia River salmon migration; however, Brodeur (1992) concluded that food availability off the Oregon and Washington coasts was not a limiting factor.

Adult salmon returning to the Columbia River migrate through the river mouth throughout the year. The majority move through this area from early spring through autumn.